JET PROPULSION LABORATORY

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10/15/02

TO: K. Oxnevad

FROM: Logistics and Technical Information Division

SUBJECT: Notification of Clearance - CL#02-2644

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Concurrent Design: A Winning Cross-Disciplinary Analysis and Design Approach

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☐ ABSTRACT (for publication) ☐ WEB SITE ☒ ORAL PRESENTATION
☐ FULL PAPER (including poster, video, CD-ROM) ☒ OTHER _____ ☐ Abstract ☐ Full Text

TITLE: Concurrent Design: A Winning Cross-Disciplinary Analysis and Design Approach

OTHER AUTHORS:

☐ Premeeting publication
☐ Publication on meeting day
☐ Postmeeting publication
☐ Poster session
☐ Handouts

KEY WORDS FOR INDEXING *(Separate terms with commas)*: Concurrent Design: A Winning Cross-Disciplinary Analysis and Design Approach

THIS WORK:
☐ Covers new technology not previously reported
☐ Covers work previously reported in New Technology Report (NTR) No. _____
☐ Provides more information for earlier NTR No(s). _____
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The NPDT

Concurrent Design: A Winning Cross-Disciplinary Analysis and Design Approach

A
Talk in the
CSMISS IT Spotlight Series

Presented
by

Dr. Knut I. Oxnevad

Jet Propulsion Laboratory
California Institute of Technology

October 16, 2002

Pasadena, CA, October 16, 2002

1. The Starting Point
2. Approach
3. The NPDT
4. Development Path
5. A Winning Approach
    a, Loihi
    b, OSIRIS
    c, Mars Rovers/Landers
5. Research
6. Future

The work described in this presentation was carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Contributing Organizations

Jet Propulsion Laboratory (JPL)/California Institute of Technology

- Mission Development
- Modeling and Simulation
- Payload Division
- Ground Operations
- Power
- Science
- Thermal
- Telecom
- Mars Rover Technology

Mars Program Office

NASA

- Code FT HQ
- Marshall
- Langley

NASDA

- Tsukuba Space Center

Concurrent Design Laboratories - CDL

Stanford University, CA

Old Dominion University, VA

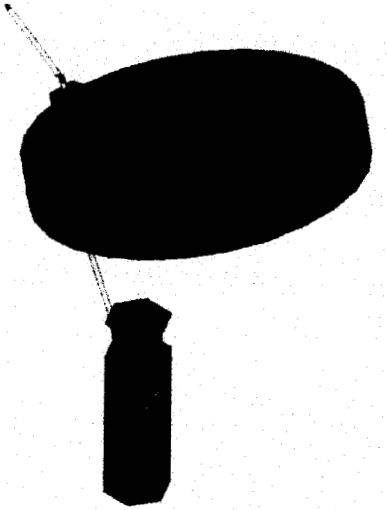
Track Record...

Concurrent Design Teams
Supported ~ 60 Studies
Over the Last 3 Years

a

Loihi

[redacted]



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IIP / OSIRIS

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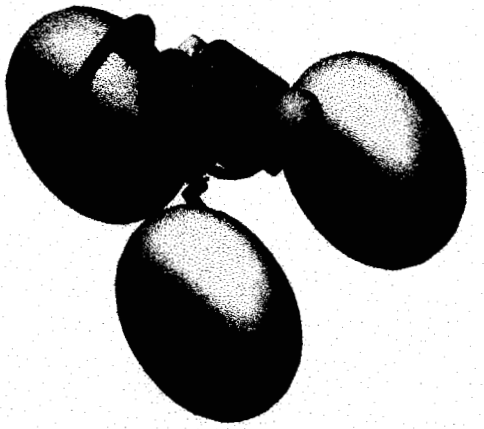
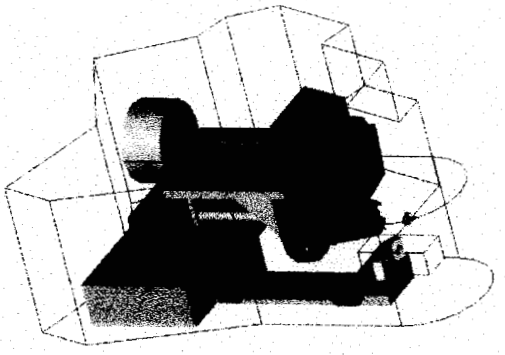


Mars Outpost
Rover

[redacted]



DS (ST)-4 / CIRCLE

Design Maturity
Improvements as
Time Compression

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The Initial Steps...

Need for Engineers and Scientist To Work more Efficiently Across Disciplines to Develop Space Systems of Higher Quality in Shorter Time

Dissertation/
Research LaRC (6.5 Years)

New Approach to
SC Design (Full Set of Equations
Describing Dynamics
Between all Subystems, Trades,
Sensitivities, etc.)

NEED: For Higher-End
Analyses and Design
Capabilities from the Start

"Eight Principles
Of Concurrent
Design"
(EUSEC2OOO)

Team I
NPDT
(Studies/Dev)

Concept to Prototype

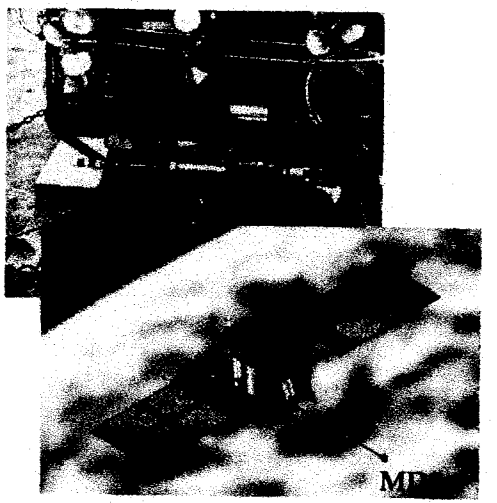
Concept to Flight Ready System

Goal!

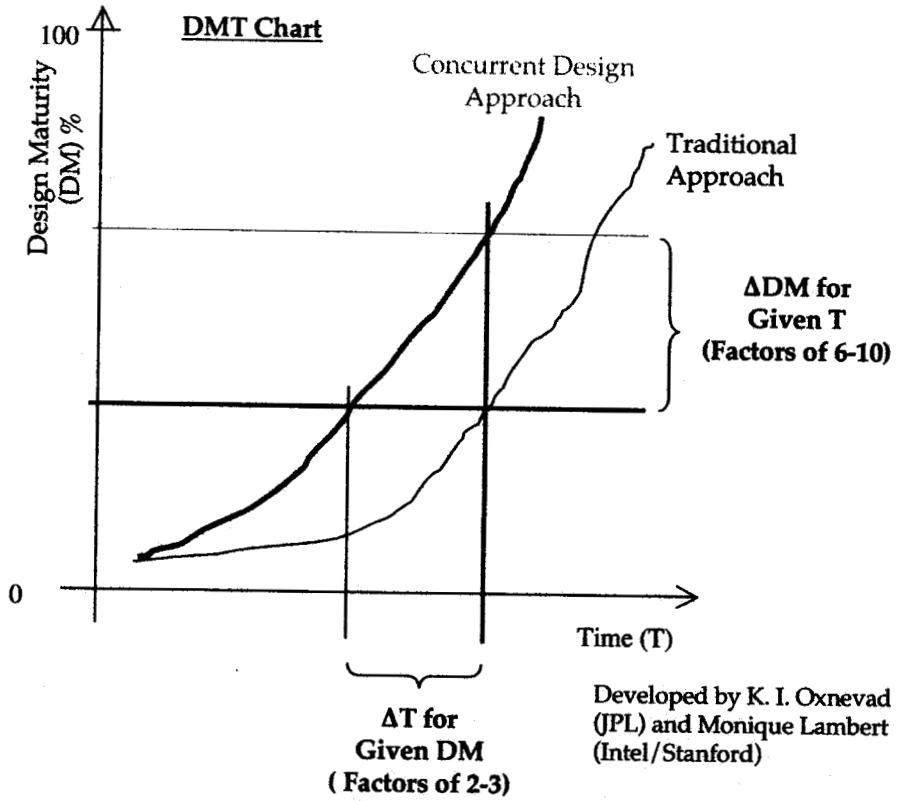
Concept

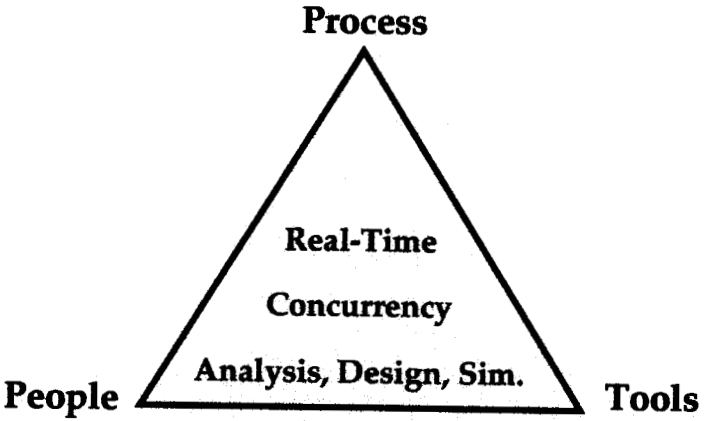
Compressed Design Cycle & Improved Quality

Space System (HW/SW)



It's About...





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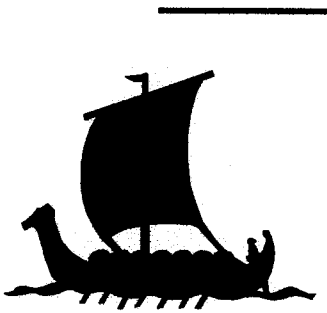
A Historical Perspective



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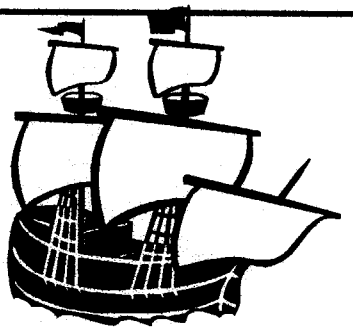

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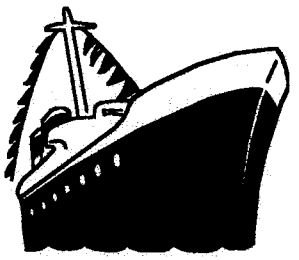
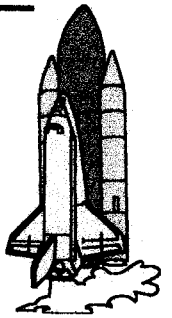
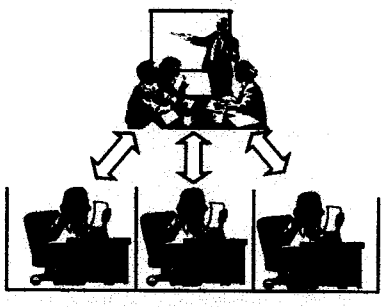
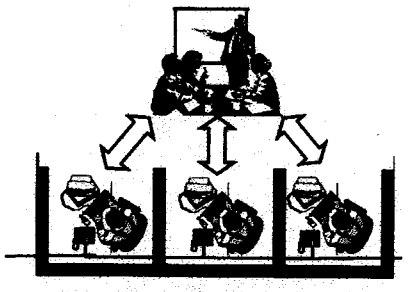


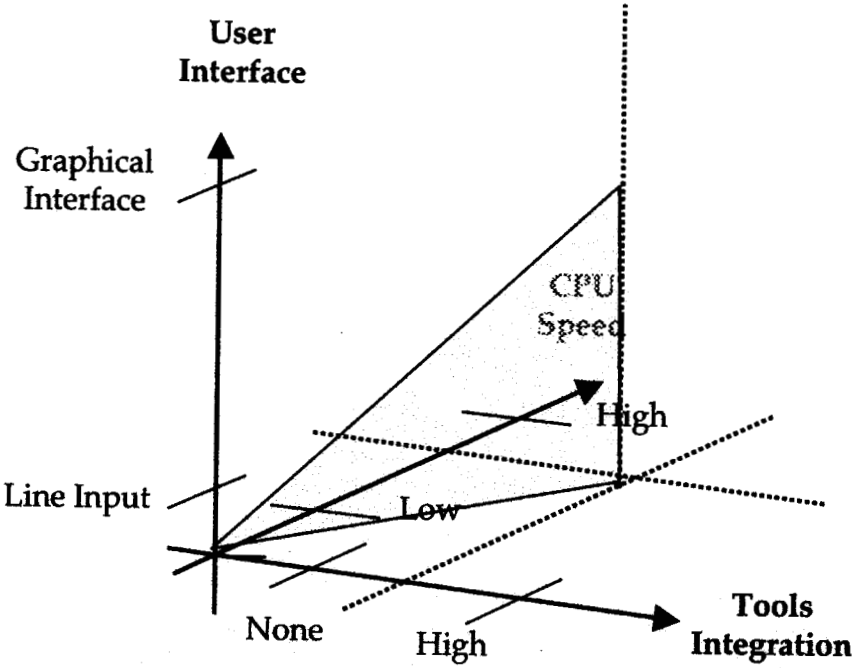
1950

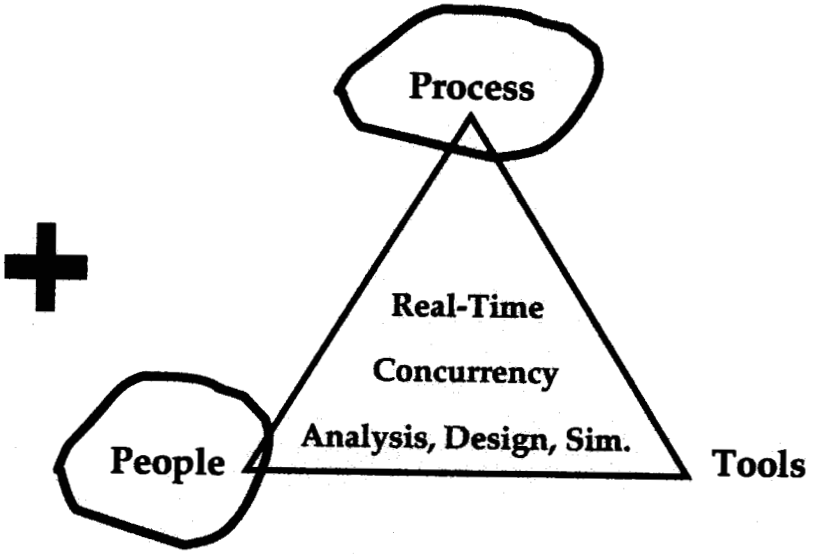


1995

Design Complexity	**Low**	**Medium**	**High**	**Very High**
Basis for Design Decisions	**Experience**	**Experience (H) Computations (L)**	**Experience (L) Computations (H)**	**Experience (VL) Computations (VH)**
Design Collaboration				
Design and Analysis Approach	•Real Time •Working Design Sessions •Hands-On/"Touch and Feel" •Designer and Builder the same	•Real Time •Working Design Sessions •Hands-On/"Touch and Feel" •Designer and Builder Co-Located	•Off-Line •Office Work •Meetings •Design Reduced to Drawings and No. •Designers and Builders Separated	•Off-Line •Office Work •Meetings •Design Reduced to Drawings and No. •Designers and Builders Separated

How to Get There





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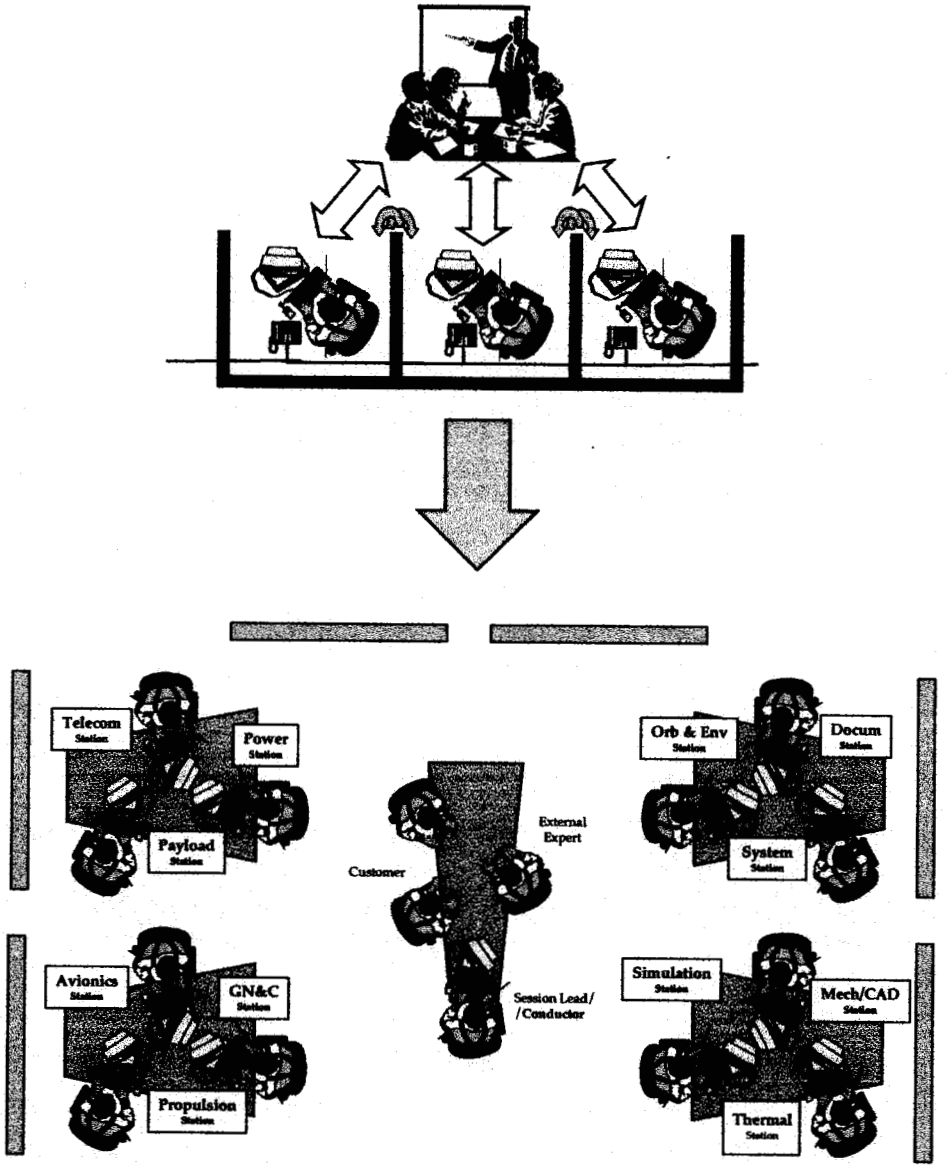
Working Design Sessions
Concurrent Design



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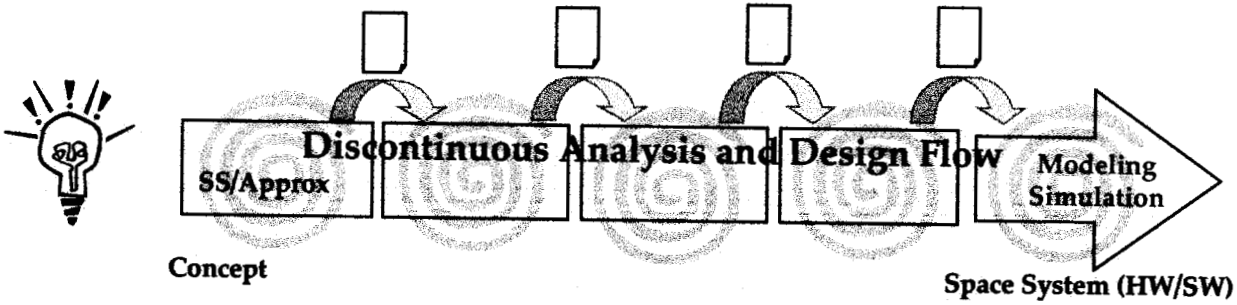
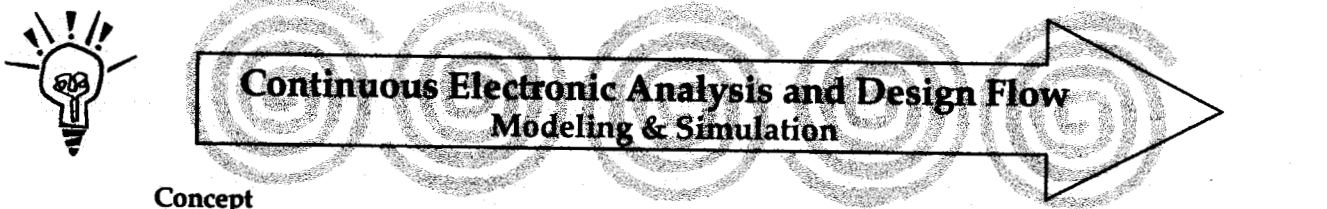
Design Flow Improvements





a

b

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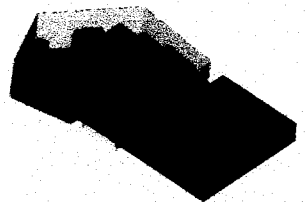
In A Nut Shell

Discovery Phase 1
Gulliver



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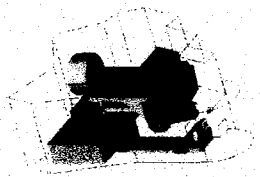
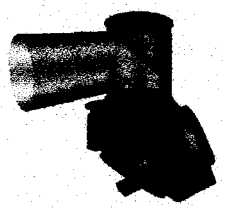
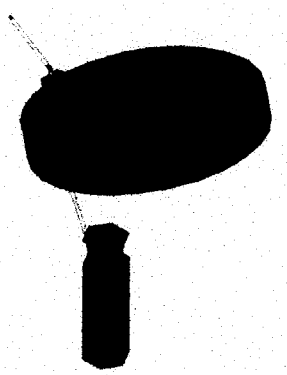


Search Camera for the
CNES Orbiter

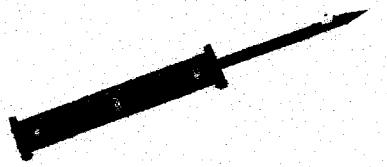


- *Concurrent **Design** and **Analysis** Environment*
- ***Real-Time** Analysis and Design*
- *Total **Systems** Approach, Multi-Disciplinary Team*
- *Standing Design Team*
- ***Customer** Actively Participates in the Design Sessions*
- *Input Parameters are Challenged in Real-Time*
- *Involved External Experts in the Design Sessions*
- *Joint Sessions with other NASA Centers*
- *From Concept to Engineering Drawings*
- ***Interconnected, High-End** Optical, Microwave, Mechanical/CAD , Thermal, Structural, Dynamics, Simulation, Orbital, Electronics Analysis and Design Tools, such as Code V, ZeMax, Mechanical Desktop, (Inventor), NASTRAN, Thermal Desktop, Adams,MODTool, and visualNASTRAN + (PowerTool, Telecomm,. Avionics)*
- *Applications Utilize a **Common** CAD Developed **Geometry***
- *Open Environment, import/export of STEP, NASTRAN files, etc., from/to JPL, other NASA centers, and Industry*
- *Technology Insertion Through Cooperation with MDL/TAP*
- *Analysis and Design Time Cut from Months to Weeks*

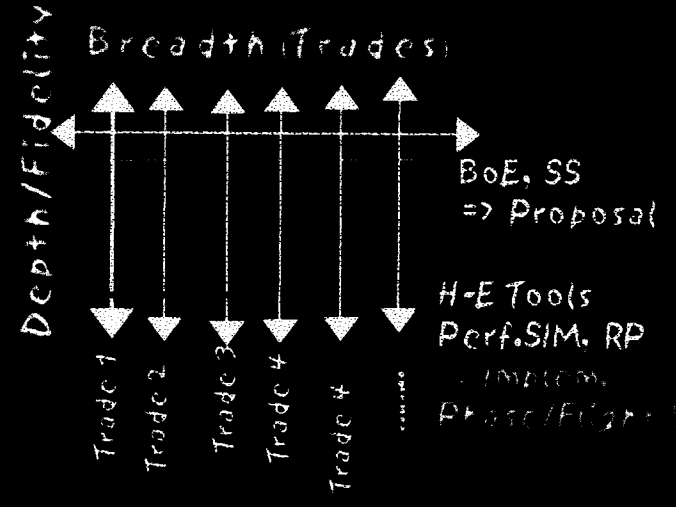
IIP/OSIRIS



Loihi Deep Ocean,
Volcanic
Vent Probe



"The Eight Principles of Concurrent Design"



(1) Analysis and design activities are performed by a MULTI-DISCIPLINARY design team

(2) Design team members work together in CONCURRENT SESSIONS

(3) "Customers" and team members participate in the concurrent sessions

(4) Analyses and design activities take place in a CONCURRENT, AND NEAR REAL-TIME fashion

(5) INTER-LINKED HIGH-END COMPUTER TOOLS are utilized in the concurrent sessions by the team members

(6) These high-end computer tools are used FROM THE EARLY PARTS OF THE DESIGN CYCLE

(7) COMMON geometrical DATA (CAD) is SHARED electronically BETWEEN the TOOLS

(8) CAD, structural, thermal, and optics data can be IMPORTED and EXPORTED to and from the design team.

EUSEC 2000

© CDL

The Steps...

Related

International IT Award

ISU SSP

"8 Principles of CD" (EUSEC2000)

MSFC CDE (NASA HQ)

[redacted]

UoM

New Paradigms Workshop (NASA HQ)

Stanford

Team I -> NPDT

Team I -> Div 38

MSMS Team Set Up

SURF (LATIS)

SURF (MEGAROVER)

John Deere

R &D

Optical
Mech
Thermal
Syst
Cost

Structural

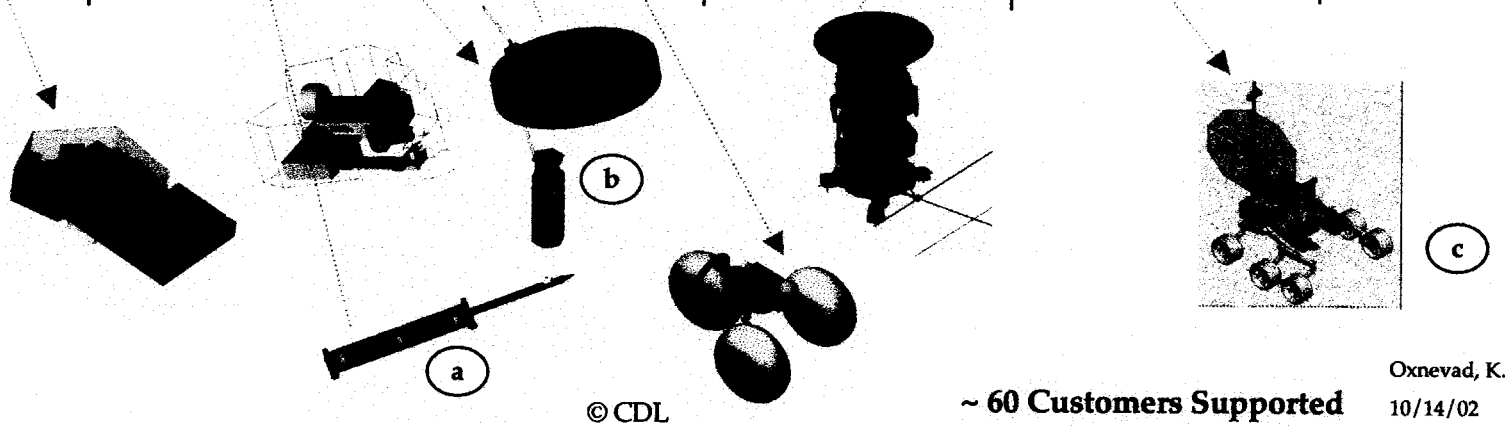
Simulation
End-End Syst
Imp/Exp Ext Files
Super Computer

Radiation
Calculations

Power Sim
Telecom
Avionics
Ground Systems

1997 | 1998 (5) | 1999 (12) | 2000 (28) | 2001 (2 +) | 2002 (?)

Customer Support



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~ 60 Customers Supported

Customer Statements

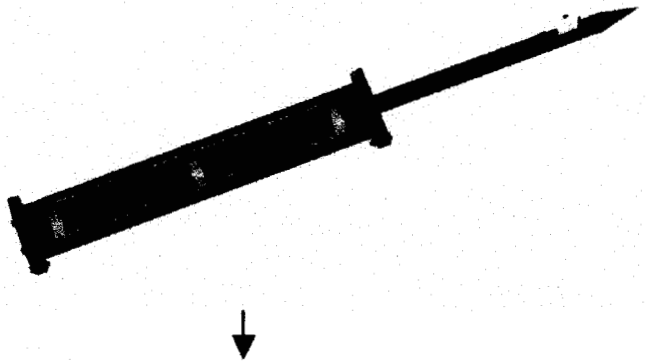
Loihi Team Member: Without Team I, it would have been impossible to get the Loihi probe done in time…

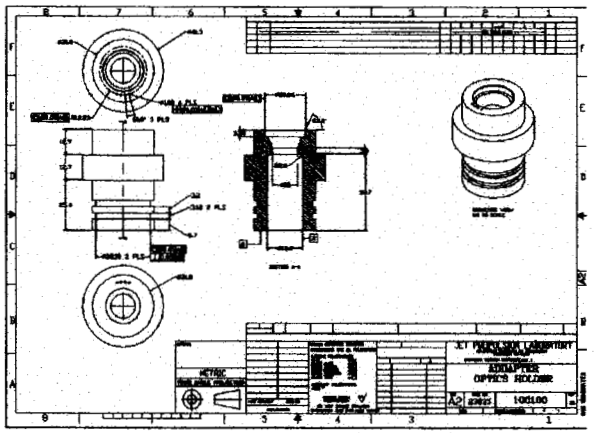
OSIRIS Team Member: The NPDT/ Team I contributed to making these winning proposals and flying missions

OSSM Team Member: My design is very mature at this point, and it does not make any sense to add on 30 % of reserves; and besides what will I be doing the next 1.5 years…

Concept -> Eng Drawing Qual in 3 Weeks

Intergrated: Opt, Mech, Struct

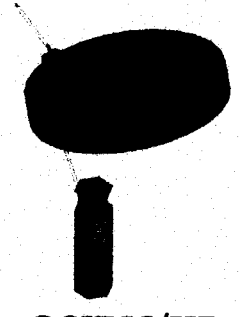




Support: Mechanical (parts and assemblies), Structural, Electronics, Optics, and Engineering Drawings

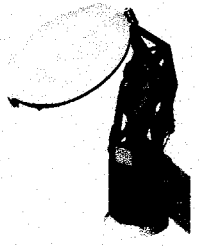
Images Courtesy G. Olarte & G. French

OSIRIS -> AQUARIUS and HYDROS
Genealogical Path



OSIRIS/IIP
(SPIN/2)
Taurus 2210

OSSM/ESSP
STATIC/3
Taurus 2210



AQUARIUS/ESSP
(STATIC/3)
Delta II 7320

NEXT

HYDROS/ESSP
(SPIN/1)
Taurus 2210

..... > **NDPT/(TD): Data, Geometries, Analysis Results (DGAR)**

------ > **TD: (DGAR)**

(b)

OSIRIS: Ocean-salinity Soil-moisture Integrated Radiometer-radar Imaging System

Images Courtesy G. Olarte & ESSP / HYDROS URL & S. Yueh

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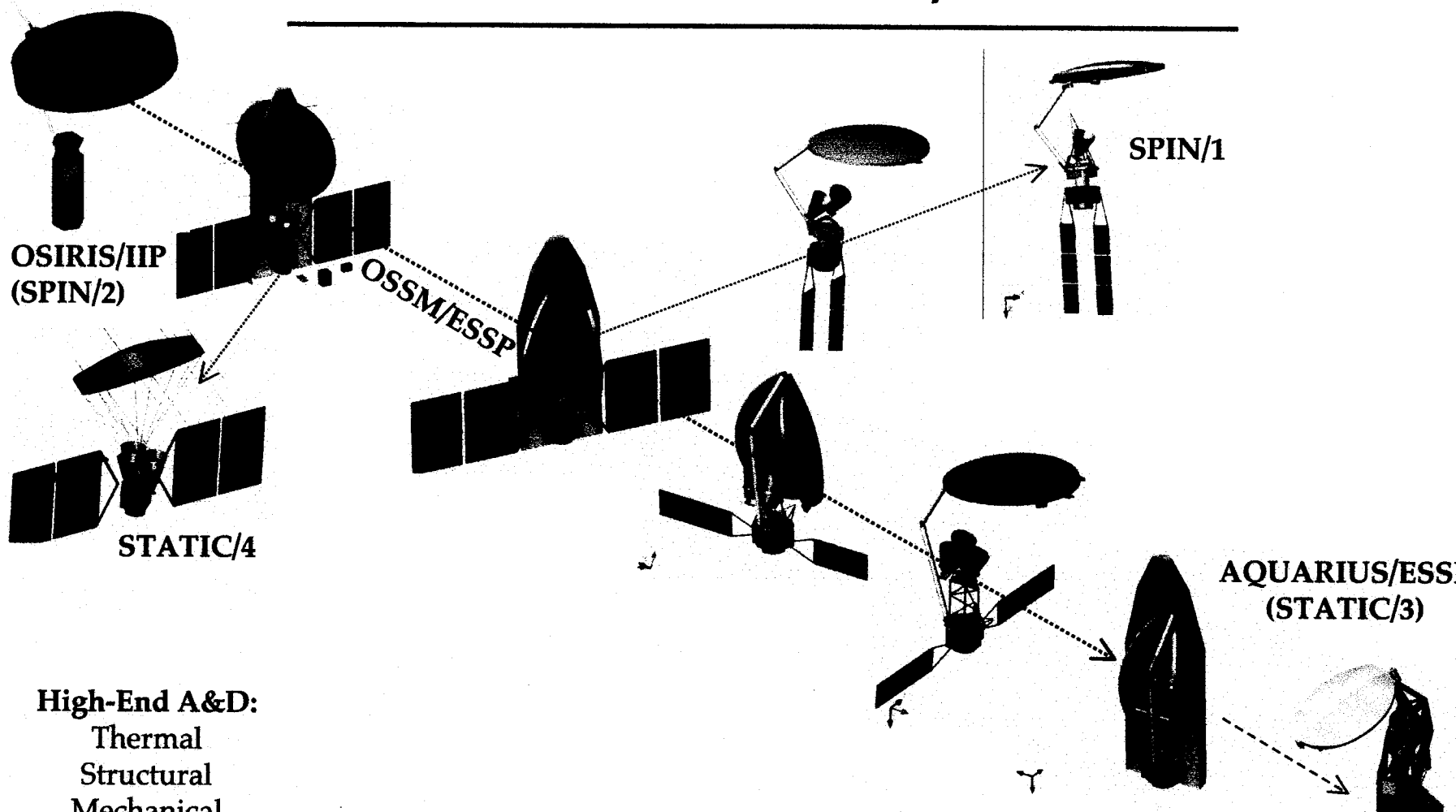
OSIRIS to AQUARIUS
Breadth and Depth



High-End A&D:
Thermal
Structural
Mechanical
Optics/Energy
Sizing & Configurations
Manufac/Materials/Test

NPDT/(TD): Data, Geometries, Analysis Results (DGAR) → **TD:~(DGAR)**

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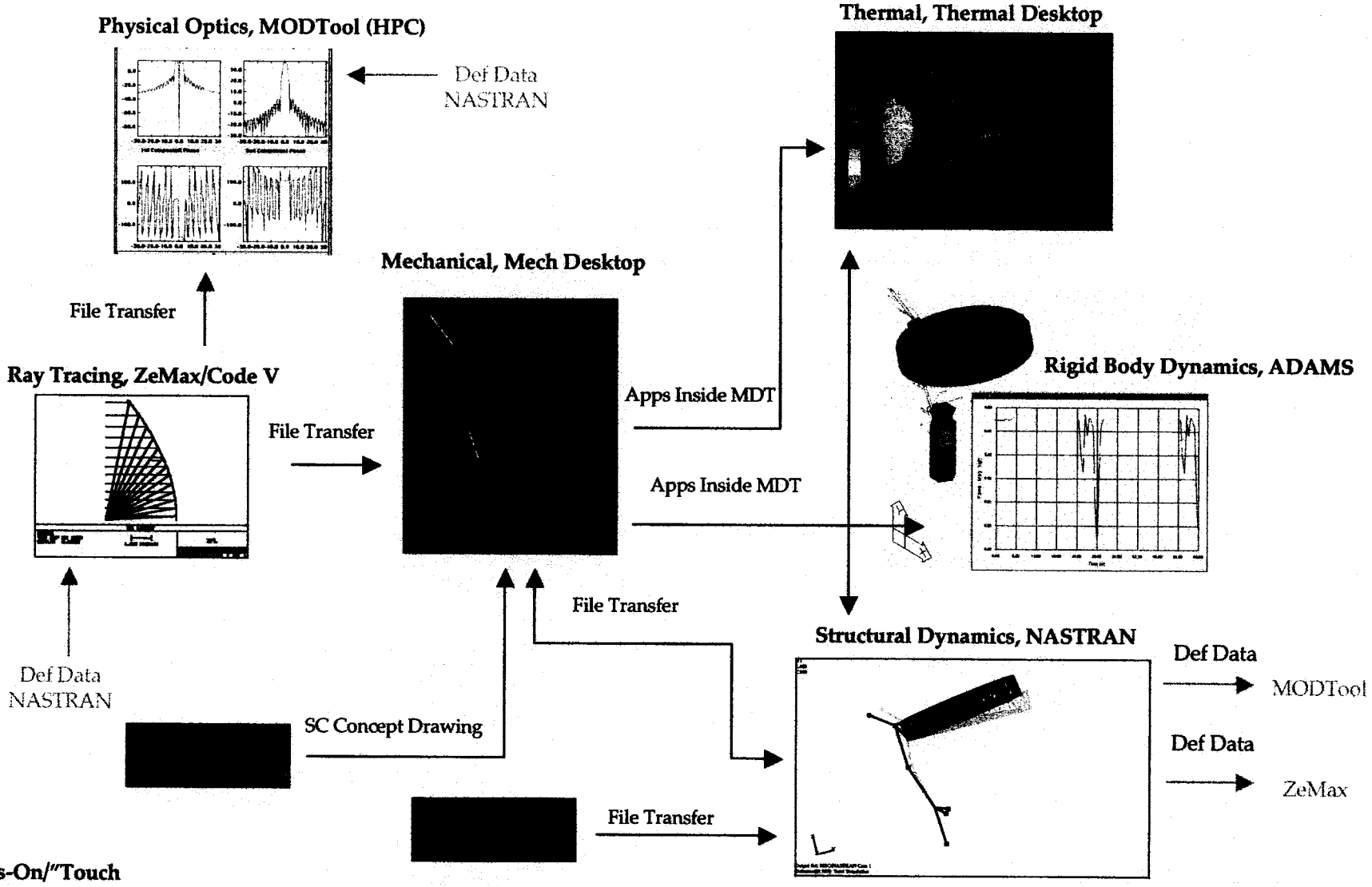
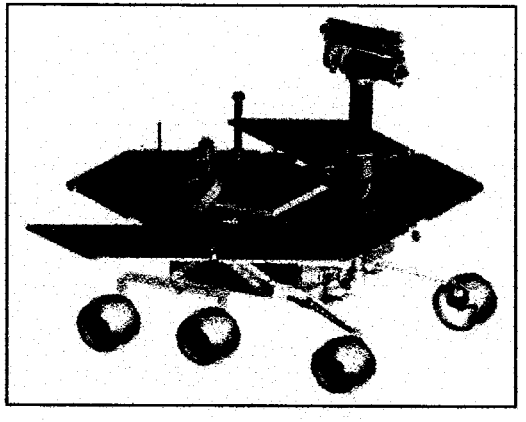
Integrated, High-End Analysis and Design



•Hands-On/"Touch and Feel"

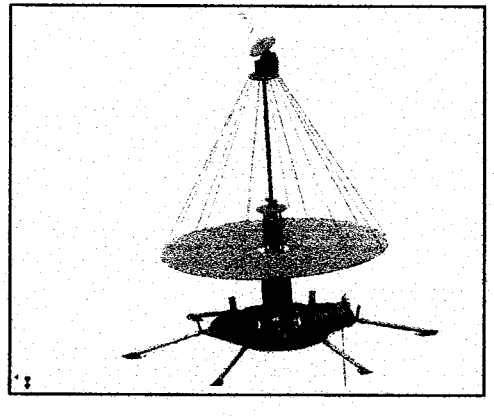
Mars Surface Mobility Studies
Mars Advanced Studies



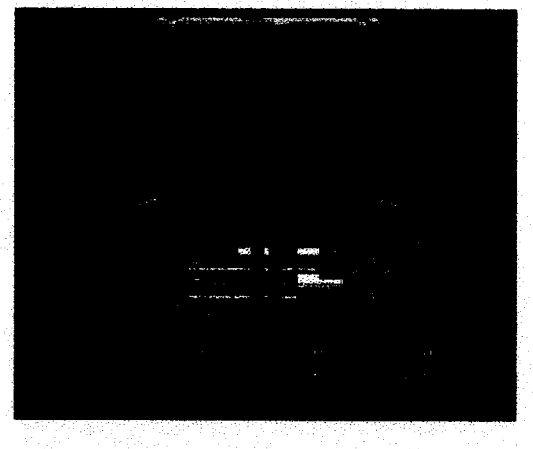
Volcanology, MER Derivative

Polar Layer Deposit (PLD)

b



Fission Powered Polar Based Cryobot Lander Mission

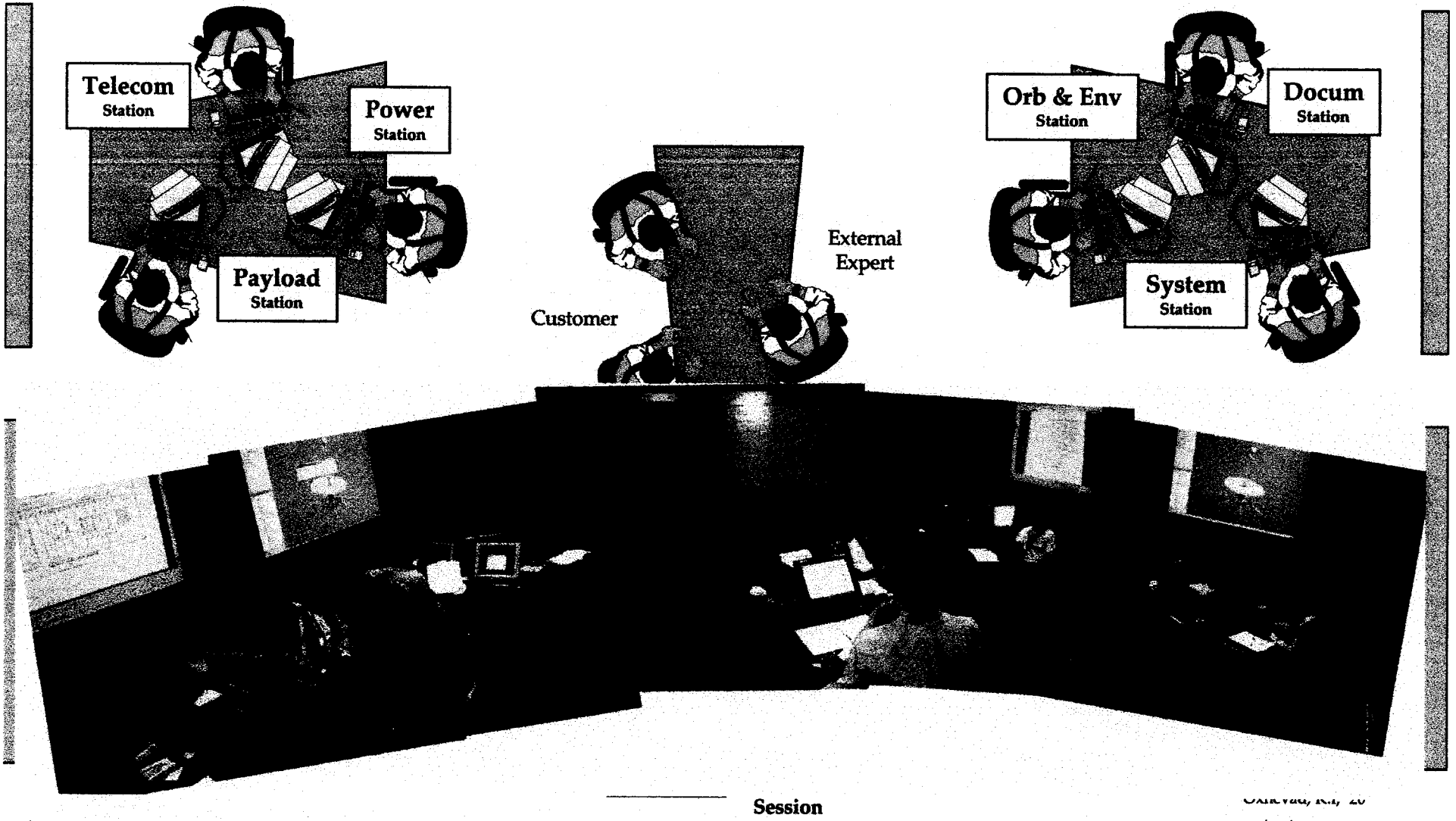


Fission Powered Rover Mission

JPL, DoE, Los Alamos, Sandia

Images Courtesy Hovik Nazaryan and Guillermo Olarte

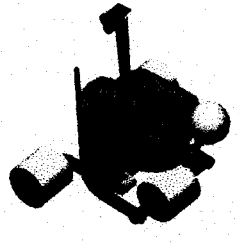
The Mars Surface Mobility Study (MSMS) Team



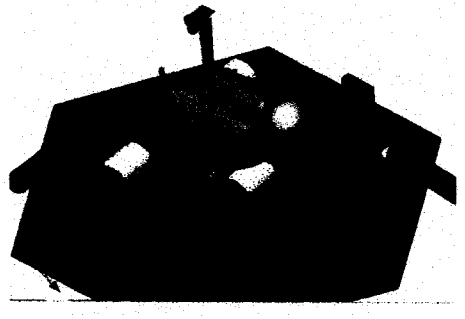
Photo, Courtesy Ben Shaw

Sizing, Configuration, and Simulation

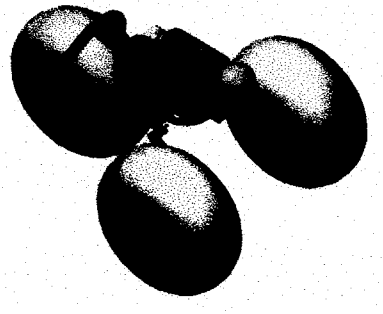
Mars Outpost
50km Fuel Cell Rover



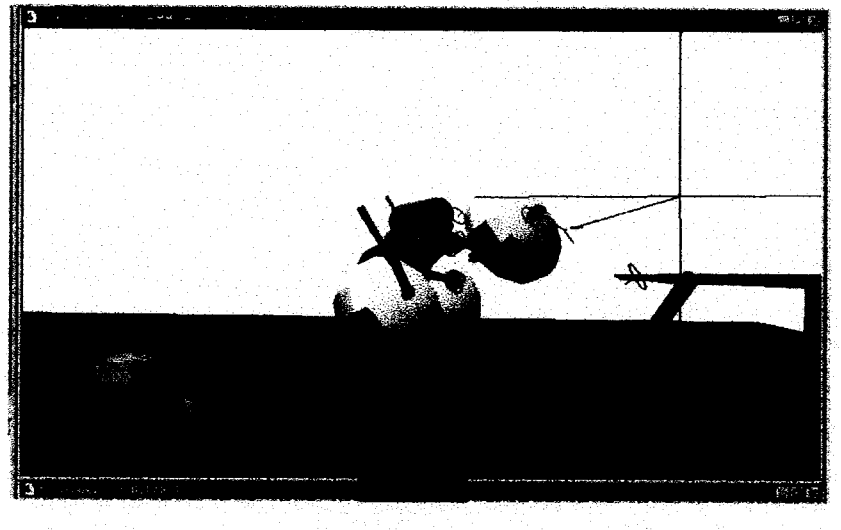
Lander Configuration



Deployment Sequence

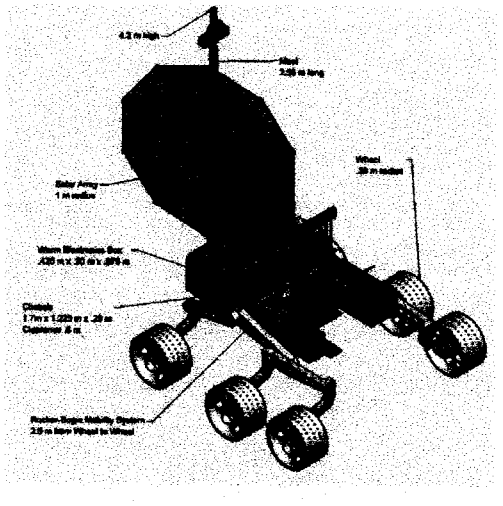


Surface Configuration



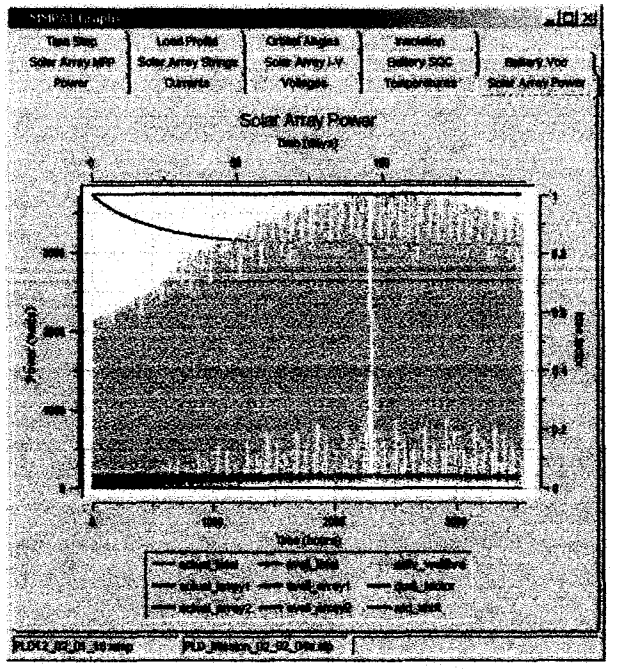
Operational Scenario Simulation

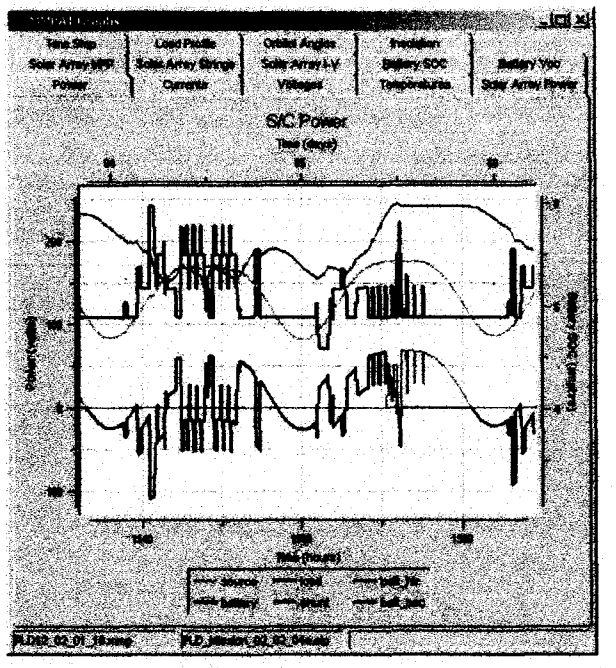
SURF 2001 Rover
(MSMS Rover Team)



Support: Mechanical (parts and assemblies), Structural, Surface Mobility/Ops Simulations, Trade Studies, Mass Summary

Power Analysis/Simulation Tool
Multi-Mission Power Analysis Tool (MMPAT)





JPL's Multi-Mission Power Analysis Tool (MMPAT) Included in Environment

Calculates, for a Given Location, Date, and Mission Power Profile:

- Solar Power Available
- Battery Charge and Voltage
- Solar Panels and Battery Sizes/Capacities

Plan to Introduce Avionics and Telecom Tools Later

Images Courtesy Erik Wood

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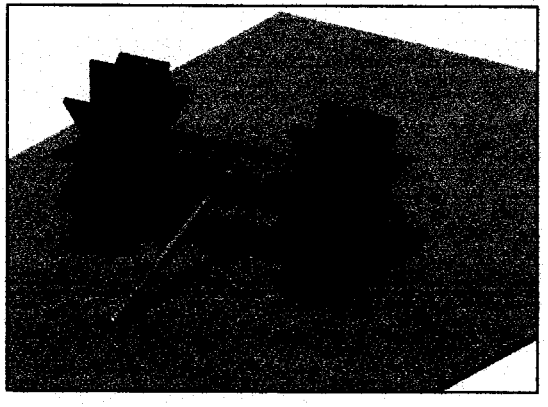
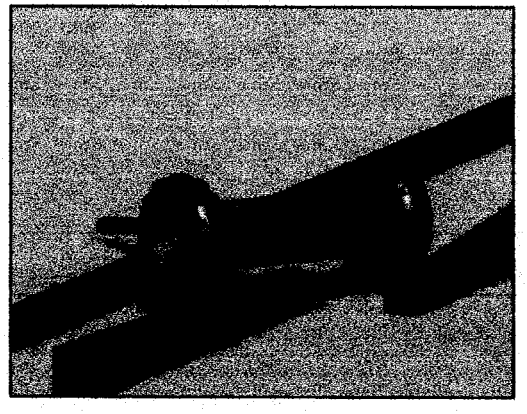
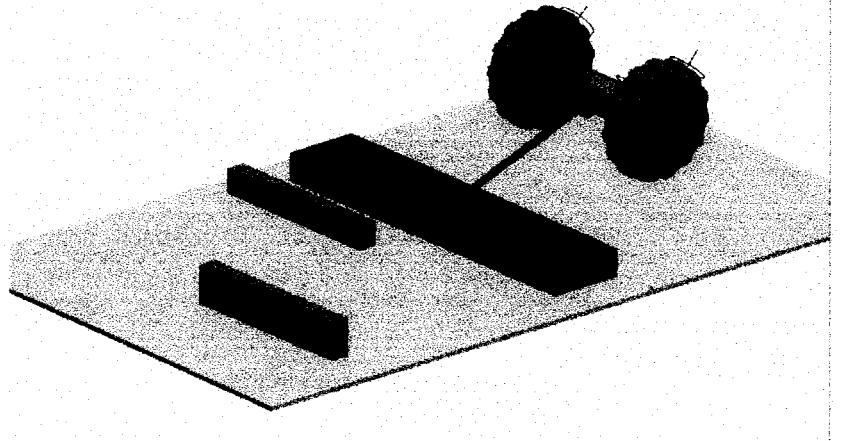
Simulation/Virtual Testing





Trades

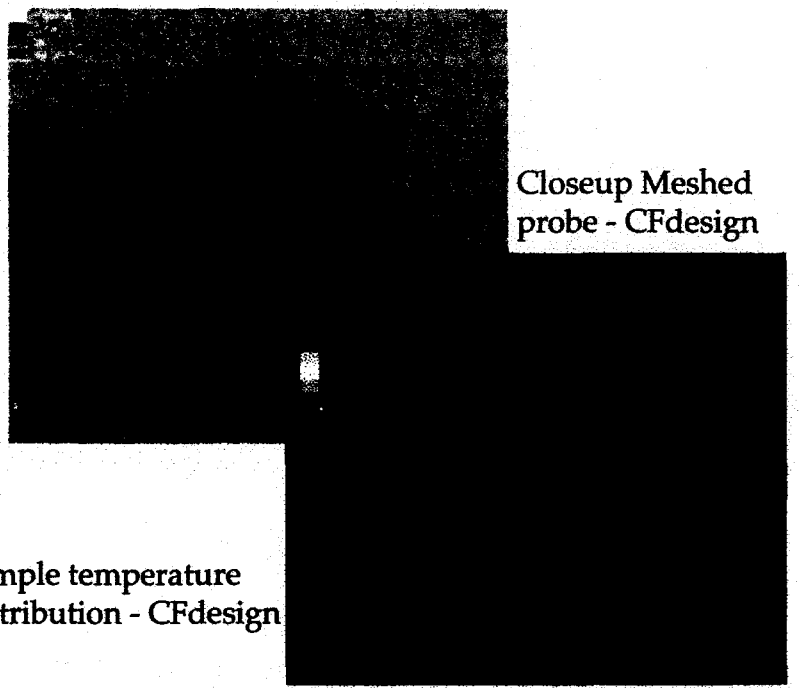
Wheel Diameter
Castor length
Wheel Base
Wheel plus rim
Castor Mass
Axelrod Mass
Axel Mass



Tools Used
Inventor
and visualNASTRAN

Images Courtesy Hovik Nazaryan and Guillermo Olarte

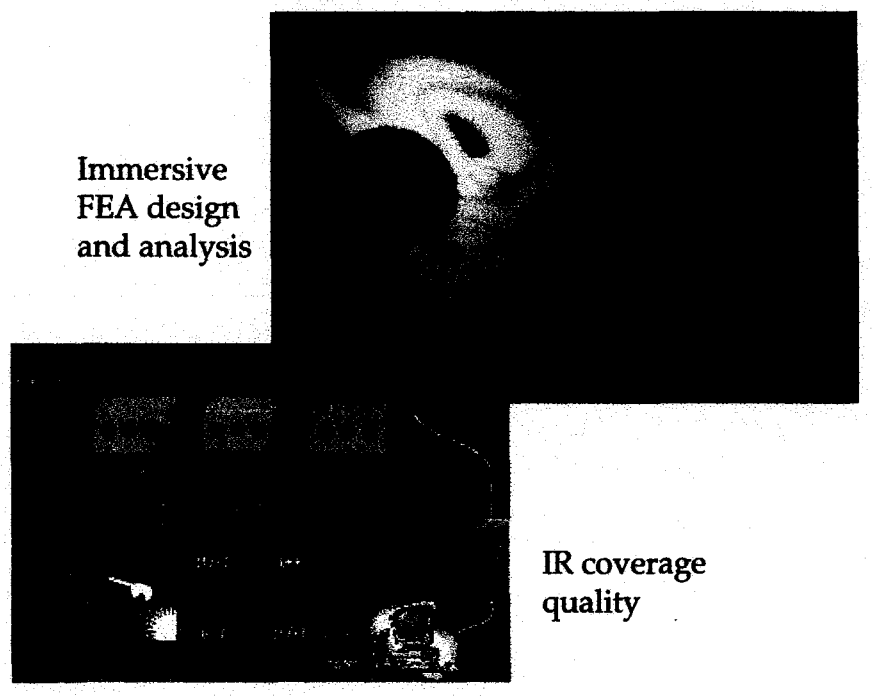
CFD and Immersive 3D COTS Tools



Closeup Meshed probe - CFdesign

Sample temperature distribution - CFdesign

Dr Tibor Balint, Assessment of Commercial Off the Shelf Computational Fluid Dynamics (COTS-CFD) Tools to Enhance the Concurrent Design Environment at NASA-JPL, JPL, May 2002



Immersive FEA design and analysis

IR coverage quality

Yves Rubin, Using 3D Visualization and Virtual Reality to Enhance the Concurrent Design Environment at NASA-JPL, May 2002

Objective

Evaluate CFD and 3D Immersive Tools For use in a Real-Time Concurrent Design Environments

<u>Evaluation and Recommendation Completed</u>

Courtesy, Dr. Tibor Balint and Yves Rubin, 2002

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Future Directions

- Develop An Art to Part Design Process for space vehicles (Concept to Hardware)
- Better Utilization of COTS tools in the Analysis, Design, and Simulation Areas
- Better Utilization of STEP
- Use of HPC (supercomputers, parallel computing systems)
    - CFD, Thermal, Structural)
- Utilization of Concurrent Design Teams **throughout** the **Design Process**, and throughout the **Organization**
- Define, train, and **set up of new Design Teams** (JPL, NASA centers [MSFC, LaRC, NARC,], NASDA, **industry**, and academia [Stanford, MIT, University of Michigan])
- Develop a Weeklong Concurrent Design Training Class for NASA Engineers (NASA Code FT)
- **New Design Paradigms** Series of **Workshops** (http://newdesignparadigms.jpl.nasa.gov)
- Develop Working **Relationships with Academic Organizations** / Initiate Research
    - Caltech (SURF, on-going)
    - International Space University (ISU)
    - MIT, Stanford, University of Irvine California, Pasadena Art Center, University of Southern California (TBD)
    - University of Michigan (April 2002)
- Port Concurrent Design Approaches to New Sectors